Security and Damage Potential of Commercial Radioactive Sources

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Abstract

The planning and execution of attacks with radiological weapons is well within the capabilities of both transnational and local terrorist groups. This refers to the illegal acquisition of the radioactive material, to the design of a weapon, and to the actual execution of an attack. In this pilot study, plausible attack scenarios have been developed based on medical and industrial sources widely used in Germany. Special emphasis was put on how such sources could be obtained by a locally acting terrorist group using criminal tactics. To this end, sources handling and daily work procedures in hospitals and companies were analysed to find weak points that could be discovered and exploited by terrorist groups. This led to recommendations for modest but visible security improvements. Based on our interviews with the staff of various facilities, we also call for a change of mentality of users and manufacturers to take into account not only safety but also more thoroughly security aspects of the use of radioactive materials.

We also estimated, by means of simulations, the damage caused by a radiological attack using the sources potentially available within the country. None of the scenarios we investigated led to doses at the site of the explosion which might cause acute radiation effects. However, in some scenarios, an attack would result in the necessity of a potentially very costly clean-up of large urban areas.

Introduction

The extensive discussion of radiological weapons in the media and in the scientific community has led to the result that such devices must now be considered part of the canon of potential terrorist methods—even though no such attack has actually occurred so far. It is therefore very important that all aspects of the threat be understood. This includes the availability of materials for terrorists and the technical hurdles they may face designing a weapon. It also includes estimating the damages such an attack would cause and preparing the equipment and procedures necessary for emergency responders to cope with it.

This work is based on a pilot study carried out by the authors at the University of Bremen in 2005 and 2006. It is focused on two aspects of the radiological weapons threat: the availability of radioactive sources for terrorists and understanding the effects of an attack with potentially available sources. Both these aspects are analyzed from the point of view of a local terrorist group based in Germany. In our scenarios, such a group would use criminal tactics (as opposed to military commando-style operations), would have sufficient technical background but potentially only limited concern for their own health. The questions we asked were:

- How could such a group acquire radioactive material?
- What amount of damage could such a group cause with a radiological weapon?

Acquiring Radioactive Materials

There are two conceivable routes to radioactive materials for terrorists. The one most talked about is the illegal acquisition in a foreign country followed by the smuggling of the source into the country where the attack is to be carried out. Such a scenario would require the logistics of a transnational group and involve many people. It may also require cooperation with organized crime. However, it is a plausible scenario and one that has drawn the attention of various national and international bodies working to improve materials security in countries of the former Soviet Union and elsewhere and to step up border security to prevent illicit trafficking of such materials.[1]

A second—and less talked about—scenario involves the stealing of radioactive sources from facilities within the country in which the attack is to be carried out. From the point of view of a European country, such scenarios are becoming more likely as terrorist cells are becoming more autonomous and in some cases may form and act completely independent of transnational terrorist organisations. Examples for these developments are the attacks in London in July 2005 and the attempted attacks by two Lebanese students on two trains in Germany in July 2006.

One obvious way to illegally acquire radioactive sources within a European country would be theft from a medical or industrial facility in which they are used. According to an estimate by the Commission of the European Communities, about seventy radioactive sources are lost every year in its member states.[2] This means the sources are no longer accounted for, i.e., they have been stolen, been illegally disposed of, or are otherwise untraceable for the responsible authorities. For the United States, the

corresponding estimates are 300 lost sources per year.[3] Only part of them are recovered, many times at scrap yards. Not all of the lost sources have a large radioactive inventory. But the sheer numbers illustrate that control and security of radioactive sources is not only a problem of the successor states of the Soviet Union and of developing countries. Recognizing the need for action, there have been European initiatives in the past years. In Germany, these have led to new legislation for the control of highly radioactive sources and to the set up of a nationwide central register for such sources in 2005.[4]

Regardless of these most welcome developments, questions remain about the actual state of security and protection against theft for medical and industrial sources. Our pilot study attempted to look at these questions for the case of Germany, a country with a highly developed security culture, with comprehensive legislation and functioning institutions supervising facilities and enforcing the corresponding legal provisions. Lessons learned from our study should be useful for other European countries and for the United States as well.

In order to investigate the security of radioactive sources, we analyzed facilities and working procedures at locations where such materials are used or stored. We located these places, mostly hospitals and companies, using the Internet and phone directories. Table 1 lists a number of typical sources we have encountered. We then visited the facilities and talked to the staff working with the sources. We looked for weak points in the daily routine of source handling that could be discovered and exploited by a locally acting group of motivated terrorists with sufficient educational or technical background. Since this was a pilot study, the number of hospitals and companies we visited was limited. Also, not every company we approached was willing to collaborate with us. Still, our study yielded some interesting results.

Both in hospitals and industrial facilities we found that the staff was highly responsible and well informed about the legal provisions concerning safety and security of the sources in use. These provisions were accurately implemented in the places we visited. However, it was quite obvious that in all cases the center of attention lay on the prevention of accidents and harm to people due to improper use of the sources. In other words, the staff we encountered focused invariably on the safety aspects of source handling and storage. A potential risk that the sources themselves could be subject to theft by criminals or terrorists was not clearly on their minds and was therefore only insufficiently taken into account during the daily work routine.

Consequently, there appeared to be opportunities for approaching the sources unnoticed in a number of cases. In some cases it appeared to be possible to steal sources including their shielding containers. In most but not all of the corresponding scenarios, the theft would have been noticed relatively quickly, i.e., within hours. These statements refer mostly to sources with a smaller radioactive inventory.

Table 1: Medical and industrial radioactive sources considered in the study

Isotope	Max. Activity	Application
Co-60	370 TBq	Teletherapy-units for tumor treatment
Cs-137	100 TBq	Blood and research irradiators
Ir-192	7,4 TBq	Industrial radiography
Se-75	3 TBq	Industrial radiography
Ir-192	370 GBq	Afterloading-units for brachytherapy
I-131	5,5 GBq	Capsules for therapeutic thyroid applications

In cases in which sources with a larger radioactive inventory would have to be dismantled from an immobile installation like a medical irradiator or a teletherapy unit, the source handling would have posed an obstacle very difficult to overcome. For example, the improper dismounting of a typical source from a teletherapy unit would lead within minutes to extremely high radiation doses. Not only would these doses be lethal (leading to death within days), they would also be sufficient to cause symptoms like nausea and vomiting to set in while the perpetrators are still at work and on the scene.

One additional critical point that was identified during the project and that requires further study is the security of sources during transport.

Assessing the Damage of an Attack

In the second part of our study we were interested in the damage that could be expected from attacks using locally available commercial sources, identified in the first part of the study (cf. table 1). Regarding the consequences of a radiological attack in an urban environment, there appears to be a dissent in the open literature. One often cited study by the Federation of American Scientists (FAS) predicts the necessity of an evacuation of larger urban areas after a radiological attack.[5] Others disagree with such dramatic scenarios. For instance, the German Federal Authority for Radiation Protection *(Bundesamt für Strahlenschutz, BfS)* states on its Web site, that "even in the immediate proximity of the location of the release [of radioactivity], from a radiological point of view no health hazards" are to be expected "for large parts of the population."[6] We attempted to elucidate these discrepancies by simulating attack scenarios using the software HOTSPOT 2.06, which was developed by the Lawrence Livermore National Laboratory and is in the public domain. This program is based on a simple Gaussian model.

The material specific input values about resulting particle sizes necessary for such a simulation are not generally available in the open literature. For our simulations, they were chosen using plausible assumptions based on the chemical and mechanical properties of the materials. Our assumptions concur with recently published experimental data by Harper, et al.[7] In addition, we took into account the results of explosive testing campaigns conducted in 2003 under the direction of the German *Gesellschaft für Anlagen- und Reaktorsicherheit* (GRS).[8]

Since our simulations were based on a simple transport model that does not allow for detailed analysis of wind fields in urban environments, the results must be read as rough estimates. We therefore limited ourselves to studying the following questions:

- Are there acute radiation effects to be expected for people within close proximity of an explosion?
- Can emergency responders do their work in or nearby an explosion site without exceeding the permissible limits for exposure to radiation?[9]
- What is the size of the area to be decontaminated after an attack?

Quantitative results of our simulations and details about the input values for the radioactive materials and for meteorological conditions will not be published. However, some interesting findings can be summarized as follows:

- None of the scenarios involving commercial sources potentially available in Germany yielded radiation doses that would lead to acute radiation effects in the vicinity of an explosion.
- Even under unfavorable conditions involving larger but plausible amounts of easily dispersible materials, emergency responders could still work at the scene for several hours without exceeding the permissible limits for radiation exposure.
- However, such unfavourable conditions could lead to ground contaminations that would require a clean-up of large areas. For the purposes of this study, we assumed a decontamination threshold of 10 mSv per year, which is based on recommendations of the International Commission on Radiation Protection (ICRP).[10] Using this threshold, the areas to be decontaminated could be as large as several square kilometers. It must be stressed that this is a conservative estimate for a certain class of materials, which, moreover, would be difficult to obtain. For most of the sources we have considered, the areas to be decontaminated would be smaller than one square kilometer.

Material, which is less easily dispersible, would, if exploded, break into larger particles. These particles may travel a long distance from the location of the explosion. At the places where they land, there could be an increased danger for emergency responders and the population due to the concentrated high activity and resulting external dose rates.

Note that we have not attempted to determine the size of the areas to be temporarily evacuated after an attack. Within the range of parameters chosen for this study, the HOTSPOT software provides insufficient accuracy for such predictions. Given the results presented here about areas to be decontaminated based on the relatively low threshold dose of 10 mSv, we expect the sizes of evacuation areas to be significantly lower than predicted in the FAS-study cited above.

Conclusion

The planning and execution of attacks with radiological weapons is well within the capabilities of both transnational and local terrorist groups. This refers to the illegal acquisition of the radioactive material, to the design of a weapon, and to the actual execution of an attack. There are, however, obstacles that make the preparation of a radiological attack more difficult than generally assumed, especially for local terrorist groups without specialized equipment. One such obstacle is the handling of highly radioactive sources, which, if done improperly, poses severe health risks for the perpetrators. This fact alone constitutes a certain level of theft protection, which is, however, by no means sufficient.

Our study showed that even in a country with already high standards for safety and security, hospitals and industrial facilities still need to introduce at least modest improvements in source security. These include improved alarm systems and/or cameras for all the rooms in which sources are used and stored. Most importantly, any such facility needs to analyze its own daily work procedures and policies of who has access to which rooms, including the cleaning staff. Similar recommendations can be made for companies transporting radioactive sources. Inexpensive but visible security improvements could also function to discourage potential perpetrators, who may otherwise come to the conclusion that such sources are easy to steal, possibly underestimating the dangers posed by some of them.

One result from our study was manifest: there is an urgent need for a mentality change for users and manufacturers of radiation sources. While there is sensitivity for the safety aspects of source handling, there is hardly any for source security. In today's world, sources are not only dangerous to handle, they are also in danger of being abused for terrorist purposes. The formerly popular notion of "self-protecting" radioactive sources no longer holds.

Our simulations have shown that an explosive dispersal of some commercial sources widely in use in Germany will most likely not result in acute radiation hazards, even for people in the vicinity of the explosion site. Furthermore, emergency responders will most likely be able to do their work in the aftermath of such an attack. However, economic costs arising, for instance, from the necessary decontamination of large urban areas may be substantial.

The results presented in this paper hold, as mentioned several times, for radioactive sources widely in use and potentially available for terrorists in Germany. Larger sources, which could be

acquired in foreign countries and smuggled into Germany, could potentially cause significantly more damage.

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